GLOSSOPTERIS OCCURRENCES IN THE PERMIAN OF IRIAN JAYA (WEST NEW GUINEA)

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Glossopteris species predominate in the Permian floras from the south west quarter of the island of New Guinea. These include *Glossopteris iriani* Rigby, and described herein *G. jongmansii*, *G. skwarkoi*, *G. wagneri* and 5 or more imperfectly known forms, possibly new species. Fossils from these localities link the region to Gondwanaland biota. Permian Cathaysian species also occur, these have been described elsewhere.

MUCH of the island of New Guinea forms the northern extent of the Australasian plate being the area south of the main suture zone running east–west along the mountain chain forming the backbone of the island. Permian plant occurrences are all located south of the suture. These occurrences include plants representing both the Gondwanaland Flora and the Cathaysian Flora. There has been an unfortunate trend in the past to name such a flora as a 'mixed flora' implying that such a flora is an unnatural manifestation. This is not the case, all that is indicated is that the occurrences lay in a region marginal to the normal ranges of the typical floras here probably climatically determined. The Gondwanaland or *Glossopteris* Flora was substantially of temperate zone occurrence and the Cathaysian Flora substantially tropical.

The first investigator of these floras in New Guinea was Jongmans (1940) who appears to have supported the concept, then popular, that the continents in the geological past occupied substantially the same position that they do at present, that is 'the permanence of the continents'. Since then, most scientists have accepted that the present position of the continents does not reflect their positions in the past. One problem is that based on palaeogeographical reconstructions utilising data derived from the Plate Tectonics Theory the whole of New Guinea may have been far removed from any other occurrences of the Cathaysian Flora, and a land-bridge contact was necessary for seed-plants to migrate between the Cathaysian region and New Guinea. On the other hand, if the South China block was close to New Guinea, then the North China Block would have been distant from the South China Block making terrestrial contact between these two blocks difficult inhibiting plant movement. No known gymnosperm seeds from the Permian had appropriate protection for the seed to remain viable after marine immersion, and no animal vectors existed to enable marine transit to occur. Metcalfe (1996) has examined this in presenting a reconstruction which addresses the problems of marine biota distribution but terrestrial contacts during appropriate times in the Permian for the migration of gymnosperms still needs to be assessed. However, if the recent reconstruction based on data from the Earth Expansion Theory as given by Carey (1996: fig. 44) is used, the appropriate segment of New Guinea was adjacent to areas supporting both the *Glossopteris* Flora to the south and the Cathaysian Flora to the north. This is discussed elsewhere (Rigby 1998).

Jongmans (1940) described and identified fossil plants from the general region J on the locality map (Fig. 1). He identified: *Sphenophyllum verticillatum*, *Pecopteris* sp. cf. *P. arcuata*, *P.* sp. cf. *P. paucinervis*, *P. unita*, *Taeniopteris* sp. cf. *T. taiyuanensis*, *T.* sp. cf. *T. multinervis* and *Vertebraria*. It should be noted that most identifications are comparisons. He was concerned about the age of the flora (Jongmans 1940) favouring Westphalian. Correspondence he had with the late A. B. Walkom, in Sydney, suggests he also had some misgivings concerning the identifications. Some of these species are redetermined herein.

Hermes & Schumacher (1961: appendix 1) listed a number of determinations of Permian plants by C. A. Hopping. This was a preliminary listing of species differing slightly from that given in Hopping & Wagner, below.

Hopping & Wagner (1962) identified the following species in a photographic atlas with legends: *Glossopteris* sp. cf. *G. browniana*, *G.* sp. cf. *G. indica*, *G.* sp. aff. *G. retifera* (they noted these *Glossopteris* identifications were tentative), *Vertebraria* sp., *Taeniopteris* sp. cf. *T. hallei*, *Cladophlebis* sp. cf. *C. australis*, *Pecopteris monyi*,

Fig. 1. Irian Jaya (West New Guinea) showing areas where collections have been made within the Permian Aiduna Formation. **J**, specimens submitted to Jongmans (1940); **R**, specimens submitted to Rigby (1997, herein). (Map from Rigby 1997: text fig. 1.) Localities for specimens described by Hopping & Wagner (1962) are not known, but are believed to be in the same region as they also occurred within the Aiduna Formation. These are prefixed by W on Table 1.

'*Validopteris*' sp., *Sphenophyllum* sp. cf. *S. speciosum*. Some of these are also redetermined below.

Rigby (1983) issued some preliminary identifications with neither description nor illustration, based on the collections included in the present study.

Rigby (1997) described the Gondwanaland affiliate *Glossopteris iriani*, the Cathaysialand affiliates *Gigantonoclea iriani*, *Fascipteris aidunae*, and the endemic *Koraua hartonoi*, all new species. Other species of *Glossopteris* were named using open nomenclature. Some of these latter species where sufficiently detailed evidence has been preserved are named below. Some ferns remain to be studied, this includes *Pecopteris* spp.

Specimens examined by Rigby, above, were collected during field work by geologists of the Irian Jaya Geological Mapping Project during the 1979 and 1980 field mapping seasons. It is not possible to re-collect in the area as it has been under the control of a group actively antagonistic to the central government for more than 20 years.

SYSTEMATIC PALAEOBOTANY

Rigby (1997) named some *Glossopteris* leaves using letters for species names. Some of the letter-designated species have been named herein, the remaining species have been kept under the previously used letter designation. The distribution of species, all collected in the Aiduna Formation, is given on Table 1. Because of unusual circumstances, specimens are referred to by locality not specimen numbers. The probable repository will be the Indonesian Macropalaeontological Collections, Geological Research and Development Centre, Bandung, Indonesia.

Genus *Glossopteris* Brongniart (1828) 1831

Fig. 2A, B

Glossopteris iriani Rigby 1997

1997 *Glossopteris iriani* Rigby: 297–298; pl. 2, figs 1, 2; text fig. 2F.

Rigby (1997) has given the following data concerning this species repeated here for completeness in the discussion of *Glossopteris* from Irian Jaya. Figure numbers are those used in this paper.

'Description: Narrowly obovate leaf, apex acute, contracting very gradually basally, midrib broad over more than half the length narrowing towards the apex; secondary venation curving gently from the midrib to the margin, degree of arching 7°, marginal angle 55°, cross connections rare, occurring more commonly near the midrib. Cuticle and fructification unknown.

'Comparison: This species does not resemble any species from Australia, South America or India in venation pattern. *Glossopteris symmetrifolia* Anderson & Anderson 1985 from southern Africa has a similar venation, but is a larger, ovate, much broader leaf.

'Material: 80 BH 302D, holotype; 80 P 279A, 11 examples, including the specimen Figs 2A, 2B; 79 RY 189A, one example; 79 SS 7, one example.'

Glossopteris jongmansii sp. nov.

Fig. 2H

1940 *Taeniopteris* sp. cf. *multinervis* Weiss—Jongmans, p. 271; figs 10, 10a.
1997 *Glossopteris* sp. F—Rigby, pl. 2, fig. 5.

Diagnosis. Broad leaf, length unknown, leaves up to 35 mm between midrib and margin, probably

Species	Locality	J1	J2	W8	W10	W11	W12	W13	W14	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
Trizygia speciosa Royle		+				+								+	?						
Pecopteris sp. A		+		+															+	+	
Pecopteris sp. B		+																			
Pecopteris sp. C		+																			
fern frond										+	+										+
Ptychocarpus sp.		+																			
Cladophlebis sp.							+														
Fascipteris aidunae Rigby		+				+						+									
Glossopteris iriani Rigby										+			+		+					+	
Glossopteris jongmansii sp. nov.		+								+											
Glossopteris skwarkoi sp. nov.		+								+											
Glossopteris wagneri sp. nov.										+	+								+		
G. sp. cf. *G. retifera* Feistmantel								+												+	
Glossopteris sp. B					+																
Glossopteris sp. C								+		+			+								
Glossopteris sp. E									+												
Glossopteris sp. F													+								
Glossopteris sp. H													+							+	
Glossopteris sp. indet													+				+				
Vertebraria indica Royle			+					+								+	+	+			
Gigantonoclea iriani Rigby															+						
Koraua hartonoi Rigby														+							

Table 1. Distribution of Permian plants from Irian Jaya. The localities are designated **J** from Jongmans (1940), **W** from Hopping & Wagner (1962) and **R** from Rigby (1997) and herein. **J1**, Oetakwa River, field locality P. 2929. **J2**, Setja River, field locality K. P. 131. **W8**, Aidoena River. **W10**, Tipoema River. **W11**, Kenataure River. **W12**, Upper Aria River. **W13**, Poeragi well, 2188–2194 m. **W14**, Aifat River. **R1**, 79 SS 7. **R2**, 79 CP 201. **R3**, 79 RY 188C. **R4**, 79 RY 189A. **R5**, 80 AG 64B. **R6**, 80 BH 302D. **R7**, 80 P 201A. **R8**, 80 P 201B. **R9**, 80 P 201C. **R10**, 80 P 278A. **R11**, 80 P 279A. **R12**, 80 UH 200C. These are the only locality data available to me.

lanceolate?; midrib strong and prominently ribbed; secondary venation straight and parallel for most of its length, marginal angle 78°, veins curve sharply on branching from the midrib over a distance of a few mm, veins anastomose and dichotomise over this region, which is where almost all cross-connections occur, vein density along margin is 18–20 per 10 mm.

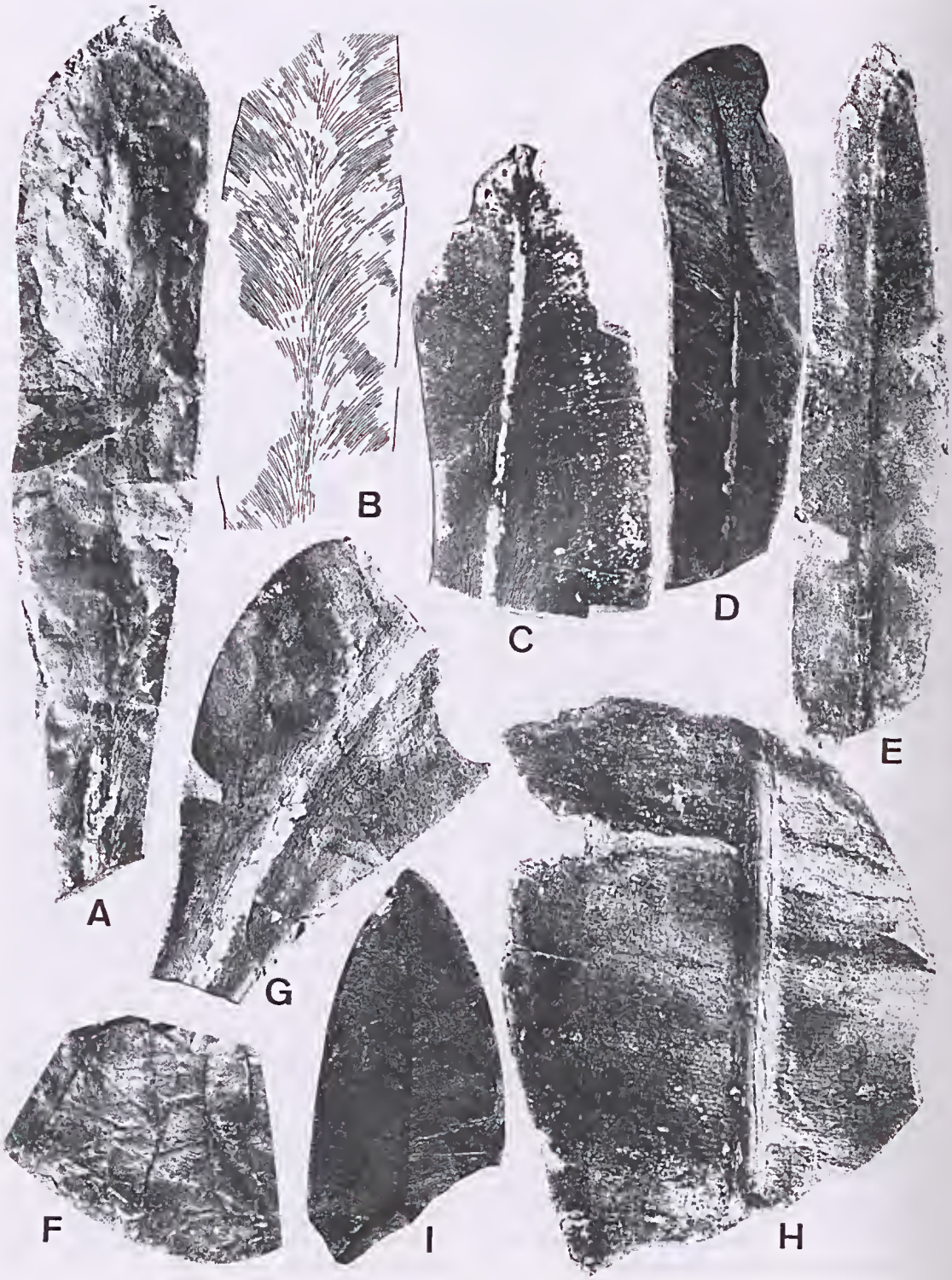
Comparison. This species has a taeniopteroid venation similar to that found in some of the larger sized *Glossopteris* leaves. *Glossopteris syaldiensis* Chandra & Surange 1979 from the Barakar Formation of India had similar, but not as strikingly open meshes in the secondary venation but extending further from the midrib, and had some cross-connections away from the midrib. *Glossopteris occidentalis* White 1908 had less pronounced areoles along the midrib and some cross-connections away from the midrib.

Discussion. Jongmans (1940) apparently either did not see or failed to appreciate the presence of cross-connections between secondary veins alongside the midrib as he considered it to be a *Taeniopteris* leaf. *Glossopteris jongmansii* had a closely similar arrangement of secondary veins to a typical *Taeniopteris* except that in the latter there was never any connection between veins after initial branching.

Holotype. Specimen shown as Fig. 2H, from locality 79 SS 7.

Distribution. Aiduna Formation, 79 SS 7, also present in Jongmans' collections.

Origin of name. After W. Jongmans, the Dutch palaeobotanist who first examined the Permian flora of Irian Jaya.


A
B
C
D
E
F
G
H
I

Glossopteris sp. cf. *G. retifera* Feistmantel 1881

Fig. 2F

1962 *Glossopteris* aff. *retifera* Feistmantel—Hopping & Wagner, figs 3, 3a, 3b.
1997 *Glossopteris* sp. D in Rigby, table 1.

Discussion. The leaf fragments examined by both Hopping & Wagner (1962) and Rigby (1997) are too incomplete to verify as *G. retifera* from the Raniganj Formation of India, but there are no other named species with a similar pattern in the secondary venation. This species recognition cannot be used as a basis for age determination as it is a comparison.

Distribution. Poeragi 1 well between 2188–2194 m (Hopping & Wagner, locality 13). Locality 80 P 279 A (Rigby).

Glossopteris skwarkoi sp. nov.

Fig. 2I

1940 *Taeniopteris* cf. *taiyuanensis* Halle—Jongmans, pp. 270–271; pl. 3, figs 9, 9a.
1997 *Glossopteris* sp. G in Rigby, pl. 2, fig. 3; table 1.

Diagnosis. The upper part only of an apparently lanceolate leaf, apex acute, midrib distinct, prominent and fairly narrow; secondary venation arises at an angle of about 60° without any significant areolar or curving region adjacent to the midrib, veins may dichotomise adjacent to the midrib, then again throughout the blade, having approximately 12 veins per 10 mm near the midrib, and 30–36 per 10 mm at the margin; there may be 3–4 anastomoses between the midrib and the margin, cross-connections are rare.

Discussion. Jongmans (1940) failed to notice the anastomoses and cross-connections between the secondary veins.

Comparison. Glossopteris skwarkoi resembles most closely *G. emarginata* Maheshwari & Prakash 1965 from the Raniganj Formation, India, for the density and pattern of the secondary venation, however *G. skwarkoi* had an acute apex and *G. emarginata* an emarginate apex.

Holotype. Specimen shown as Fig. 2I from locality 79 SS 7.

Distribution. Aiduna Formation, locality 79 SS 7, and Jongmans' locality Oetakwa River.

Origin of the name. S. Skwarko, of the then Bureau of Mineral Resources, during participation in the joint Australian–Indonesian Geological Mapping Project collected the holotype.

Glossopteris wagneri sp. nov.

Fig. 2D, E

1997 *Glossopteris* sp. A in Rigby, pl. 2, fig. 4; table 1.

Diagnosis. Linear lanceolate leaf, apex acute, tapering base apparently non petiolate, midrib prominent, narrow, with anastomosing ribbing, secondary venation arched, degree of arching 30°, marginal angle 60–65°, veins spaced 10 per 10 mm, dichotomies and cross-connections between veins rare.

Comparison. This species is similar to *Glossopteris iriani* differing in being a shorter, narrower leaf with the degree of arching of the secondary venation 30°, marginal angle 60–65° compared with *G. iriani* 7° and 55°.

Holotype. Specimen shown as Fig. 2E from locality 79 SS 7.

Distribution. Aiduna Formation, localities 79 SS 7, 8 specimens, also a few specimens from 79 CP 201, 80 P 278 A.

Origin of name. After R. H. Wagner, of the Jardin Botanico, Córdoba, Spain, who co-authored the description of the collections made by the 'Nederlandsche Nieuw Guinee Petroleum Maatschappij 1935–1960'.

Glossopteris sp. B

1962 *Glossopteris* cf. *browniana* Brongniart—Hopping & Wagner, figs 1, 1a.

Fig. 2. Permian *Glossopteris* from Irian Jaya (West New Guinea). All figures natural size. **A, B,** *Glossopteris iriani* Rigby 1997. The best-preserved example, 80 P 279A. **C,** *Glossopteris* sp. F. 79 RY 189A. **D, E,** *Glossopteris wagneri* sp. nov.: D, paratype, 79 SS 7; E, holotype, 79 SS 7. **F,** *Glossopteris* sp. cf. *G. retifera* Feistmantel, 80 P 279A. **G,** *Glossopteris* sp. H, 79 RY 189A. **H,** *Glossopteris jongmansii* sp. nov. holotype, 79 SS 7. **I,** *Glossopteris skwarkoi* sp. nov. holotype, 79 SS 7.

Not present in my collections. I am unable to offer any meaningful suggestions as to the specimen's identity based on my photocopy of the original, the only illustration I have access to.

Distribution. Tipoema River, Hopping & Wagner's locality 10.

Glossopteris sp. C

1962 *Glossopteris* cf. *indica* Schimper—Hopping & Wagner, figs 2, 2a.
1997 *Glossopteris* sp. C in Rigby, pl. 2, fig. 7; table 1.

These specimens differ from typical both *G. iriani* and *G. wagneri*, the diffcrences may bc sufficicnt to erect a new species, or possibly to show merging characters with either of these specics if morc, or better preserved material were availablc. The type specimen of *Glossopteris indica* is a very much larger lcaf with a more open, less strongly arched venation, and proportionally narrowcr midrib.

Distribution. Pocragi 1 well at 2188–2194 m, Hopping & Wagner's locality 13; Aiduna Formation at localitics 79 SS 7, 79 RY 189 A.

Glossopteris sp. E

1962 *Taeniopteris* cf. *hallei* Kawasaki—Hopping & Wagner, figs 5, 5a.

There appears to be some cross-connections between the secondary veins. I am unable to make any meaningful comparisons based on my photocopy of the original.

Distribution. Aifat River, Hopping & Wagner's locality 14.

Glossopteris sp. F

Fig. 2C

1997 *Glossopteris* sp. F (*partim*) in Rigby, pl. 2, fig. 3; text fig. 2G; table 1.

Some specimens designated *Glossopteris* sp. F by Rigby (1997) have been re-identified as *G. jongmansii* herein, from locality 79 SS 7. A specimen from locality 79 RY 189 A has been retained here. The only specimen of *G.* sp. H also came from this locality. I think both may prove to be valid species with additional material, so have retained them under separate letter designations.

Glossopteris sp. H

Fig. 2G

1997 *Glossopteris* sp. H in Rigby, pl. 2, fig. 9; text fig. 2D; table 1.

See under *Glossopteris* sp. F for discussion.

OTHER IDENTIFIED SPECIES

Besides species of *Glossopteris*, other species have been identified and discussed elsewhere. Their distribution and locality data is givcn on Table 1.

Trizygia speciosa Royle 1839

1940 *Sphenophyllum verticillatum*—Jongmans, p. 271, pl. 1, fig. 1.
1962 *Sphenophyllum* cf. *speciosum*—Hopping & Wagner, fig. 4.
1997 *Trizygia speciosa* Royle—Rigby, pl. 1, fig. 3.

Fascipteris aidunae Rigby 1997

1940 *Pecopteris unita*—Jongmans, p. 270; pl. 2, figs 7, 7a.
1962 '*Validopteris*' sp.—Hopping & Wagner, figs 8, 8a.
1997 *Fascipteris aidunae* Rigby, pp. 298–299; pl. 1, figs 4, 5; text fig. 21. (Note that fig. 5 is the holotype and fig. 4 the paratype.)

Vertebraria indica Royle 1839

1940 *Vertebraria*—Jongmans, p. 271; pl. 1, fig. 1.
1962 *Vertebraria* sp.—Hopping & Wagner, fig. 4.

Gigantonoclea iriani Rigby 1997

1997 *Gigantonoclea iriani* Rigby, p. 298; pl. 1, fig. 2; text figs 2A, 2B.

Koraua hartonoi Rigby 1997

1997 *Koraua hartonoi* Rigby, p. 300; pl. 1, fig. 2; pl. 2, fig 6; text fig 3.

Some spccics listcd on Tablc I need to be rcvised, or havc yct to be described, including: *Pecopteris* spp. A, B, C, fern frond, *Ptychocarpus* sp., *Cladophlebis* sp.

CONCLUSIONS

All taxonomically defined species are endemic to the southwestern quarter of the island of New Guinea, except for the very widely distributed *Vertebraria indica*, so cannot be used to define age more precisely than Permian. Shi et al. (1995), and references they cite, date the Aiduna Formation as lying within the range of Late Sakmarian to Early Artinskian based on faunas.

The composition of the flora indicates a land connection with regions growing both the Gondwanaland temperate flora and the Cathaysian tropical flora. All seed plants are endemic to the area, but most belong to genera found elsewhere, namely *Glossopteris* and *Gigantonoclea*.

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REFERENCES

ANDERSON, J. M. & ANDERSON, H. M., 1985. *Palaeofloras of southern Africa. Prodromus of South African megafloras Devonian to Lower Cretaceous*. Balkema, Rotterdam. 423 pp.

BRONGNIART, A., 1828. Prodrôme d'une histoire des végétaux fossiles, au recherches botaniques et géologiques sur les végétaux renfermés dans les diverse couches du globe. *Dictionnaire des Sciences naturelles* 57: 16–212.

BRONGNIART, A., 1831. *Histoire des végétaux fossiles ou recherchess botaniques et géologiques sur les végétaux renfermés dans le diverses couches du globe*. Dufour & D'Ocagne, Paris. vol. 1, pt 5, pp. 209–248, pls 50, 53, 57, 58, 61bis, 62, 64, 65, 67, 68, 70, 71, 73, 76.

CAREY, S. W., 1996. *Earth Universe Cosmos*. University of Tasmania, Hobart, xiii+231 pp.

CHANDRA, S. & SURANGE, K. R., 1979. Revision of the Indian species of *Glossopteris*. *Birbal Sahni Institute of Palaeobotany Monograph* 2: 1–291.

FEISTMANTEL, O., 1880. The fossil flora of the Gondwana System—2. The flora of the Damuda and Panchet divisions (conclusion). *Memoirs of the Geological Survey of India. Palaeontologia indica*. (12)3(3): 78–149, pls 17A–47A.

HERMES, J. J. & SCHUMACHER, F. C., 1961. Summary of stratigraphy of Netherlands New Guinea. *Proceedings of the Ninth Pacific Science Congress*: 318–324.

HOPPING, C. H. & WAGNER, R. H., 1962. Plant fossils. Enclosure 17: 1–11. In *Geological results of the exploration for oil in Netherlands New Guinea*, W. A. Visser & J. J. Hermes, eds, *Koninklijk Nederlands geologisch mijnbouwkundig genootschap. Geologisch serie, Speciaal nummer* 20.

JONGMANS, W. J., 1940. Beiträge zur Kenntnis der Karbonflora von Niederländisch Neu-Guinea. *Geologische Stichting, Mededeelingen* 1938–1939: 263–274, pls 1–3.

MAHESHWARI, H. K. & PRAKASH, G., 1965. Studies in the Glossopteris Flora of India—21. Plant megafossils from the Lower Gondwana exposures along Bansloi River in Rajmahal Hills, Bihar. *Palaeobotanist* 13(2): 115–128, pls 1–3.

METCALFE, I., 1996. Pre-Cretaceous evolution of SE Asian terranes. In *Tectonic Evolution of Southeast Asia*, R. Hall & D. Blundell, eds, Geological Society Special Publication 106: 97–122.

RIGBY, J. F., 1983. Plant fossils from the Aiduna Formation. Appendix 3. In *Geological Data Record Waghete (Yapekopra) 1:250,000 sheet area Irian Jaya*, C. J. Pigram & H. Panggabean, eds, Geological Research and Development Centre, Bandung, 91–92, 3 unnumbered maps.

RIGBY, J. F., 1997. The significance of a Permian flora from Irian Jaya (West New Guinea) containing elements related to coeval floras of Gondwanaland and Cathaysialand. *Palaeobotanist* 45: 295–302.

RIGBY, J. F., 1998. Upper Palaeozoic floras of SE Asia. In *Biogeography and Geological Evolution of SE Asia*, R. Hall & J. D. Holloway, eds, Backhuys, Leiden, 73–82.

ROYLE, J. F., 1839. *Illustrations of the botany and other branches of natural history of the Himalayan Mountains and the flora of Cashmere*. Wm H. Allen & Co., London. vol. 2, 100 pp.

SHI G. R., ARCHBOLD, N. W. & ZHAN, L.-P., 1995. Distribution and characteristics of mixed (transitional) mid-Permian (Late Artinskian–Ufimian) marine faunas in Asia and their palaeogeographical implications. *Palaeogeography, Palaeoclimatology, Palaeoecology* 114: 241–271.

WHITE, D., 1908. Fossil flora of the coal measures of Brazil. In *Final Report. Commissão de Estudos das Minas de Pedra do Brazil*, I. C. White, ed., Rio de Janeiro, pt 3, 337–605, 14 pls.